X

SUGGESTIONS

REGARDING THE

WORKING OF THE TRANS-SARDA FORESTS,

KHERI DISTRICT,

OUDH.

BY

D. BRANDIS,

INSPECTOR GENERAL OF FORESTS.

Dated Simla, the 20th August 1880.

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INTRODUCTION.

I HAVE been requested to state my views on certain proposals made in August 1879 by Captain Wood, the Conservator of the Oudh Forests, for increasing the annual fellings in the forests of the trans-Sárda Working Circle, comprising the Newalkhar and Khairigarh Sub-divisions of Kheri.

In order to guard against misconception, it will be best to quote an extract from Captain Wood's letter to the Government of the North-Western Provinces and Oudh No. 86, dated the 27th August 1879, which states his views:—

The forests trans-Sárda are the only forests in which there are timber operations properly so called. There is no proper preliminary working plan; the Government of India has arbitrarily ruled that there are only to be 2,000 large trees felled annually, the latest reason given being that, fires being still existent, it is not expedient to fell more on account of scant reproduction. Now the forests contain about 180 square miles of sál or 115,200 acres, with an average of 4·48* first class trees (large enough to be felled) or 516,096 trees in the forests. The rate of growth assumed by the Inspector-General of Forests is 10 years to make an inch of radius, or the difference between a first class tree of 6′ girth (say 2 feet diameter) and a second class tree of 4′ 6″ girth (say 1′ 6″ diameter) = 6″ diameter or 3″ radius × 10 = 30 years. The Inspector-General then says—"to be on the safe side, say 40 years." Now you can cut out the first class trees in about $\frac{1}{40}$th of the forest, and by the time you come round again in 40 years, all your trees over 4½ feet girth will have become trees of 6 feet girth; on a $\frac{1}{40}$th of the forest you have $\frac{516,096}{40}$ trees = 12,902·4, but you must only fell 3,000 of these trees, now reduced, to 2,000; so that, taking 30 years as the time that a second class tree comes to be a first, if every tree was felled, and there was no limit of safety given, we could cut 17,203 trees; so that in felling 2,000 trees a year, we only fell about $\frac{1}{8}$th or $\frac{1}{9}$th of what we could fell. This is on the 10 years to the inch theory; but my opinion backed by my experience gives five years to an inch of radius in these forests, and my opinion also is that, instead of one ring per annum there are two or more, the principal ones showing hot weather growth and the rainy season growth; the minor ones heavy frost, or fires killing the leaves and making an artificial season. If my idea is correct, we are only felling about $\frac{1}{17}$th of what we could: of course these trees are not all sound; but the Inspector-General says "leave the others for shade and seed." I say—"having got up a crop of saplings, cut them out; utilize what you can of the unsound and crooked ones, for, with a crop of saplings around them, the old ones (which are deteriorating) are only cumbering the ground."

* See Appendix IV, Oudh Forest Report, 1871-72. Captain Stenhouse gives 4·15 sál and ·62 asna, but he erred in taking his average. The corrected figures give 3·66 and 8·2 respectively = 4·48.

2. If I understand this passage correctly, Captain Wood makes two proposals—

1*st*—That a much larger number of trees yielding marketable timber be felled annually than has been done hitherto.

2*nd*—That, besides the sound and well-grown trees, which yield marketable timber, the unsound and crooked trees be also cut and utilized as much as possible.

It will be convenient to arrange my remarks under the following heads:—

Former cuttings.
Annual fires.
Growing stock.
Rate of growth.

It should be distinctly understood that the remarks of the present report relate only to the trans-Sárda Forests of the Kheri Division, and that, except where it is expressly stated otherwise, they must not be held applicable to any other forests in Oudh or other provinces.

Former cuttings.

3. Regarding the cuttings in former years, the information available is as follows:—

1861-62 to 1867-68,	7 years,	12,000*	trees,	chiefly sál
1868-69 to 1876-77,	9 years,	25,211†	„	chiefly sál, with a little asna *(Terminalia tomentosa)* and haldu *(Adina cordifolia)*.
1877-78 ...	1 year,	5,169†	„	chiefly sál, with a little asna and haldu.
1878-79 ...	1 year,	3,328†	„	Ditto ditto.
Total ...	18 years,	45,708	trees.	

Thus the annual average of the first seven years was 1,714, that of the next 11 years 3,000, and the average of the whole period 2,540 trees. No information regarding the number of sál and other trees is recorded, except that in 1878-79, 2,750 sál and 578 asna trees were cut. The total area of the forests in the trans-Sárda Working Circle is 280 square miles, of which Captain Wood states that 180 square miles or 115,200 acres are stocked with sál. Assuming this to be correct, and assuming that a tree yields on an average 50 cubic feet of wood, the average annual outturn of the last 11 years was 1,50,000 cubic feet of wood, or a little less than one and a half cubic feet per acre per annum. The forests can, and ought of course, to yield a great deal more than this insignificant quantity.

Dry timber exported by purchasers.

4. Besides the timber felled by the department, large quantities of timber, chiefly dry wood, have annually been removed from these forests by purchasers. The quantity is not stated in the annual reports, but some idea may be gathered from the amounts realized on this account, from which the quantity may be approximately calculated at 4 annas per cubic foot (paragraph 54 of Report for 1874-75). The figures are as follows:—

Timber removed by purchasers, Kheri Division.‡

	Rs.	Cubic feet.
1869-70	20,041	80,164
1870-71	10,102	40,408
1871-72	2,318	9,272
1872-73	7,422	29,688
1873-74.	24,419	97,676
1874-75	38,586	154,344
1875-76	71,974	287,896
1876-77	50,219	200,876
1877-78	16,232	64,928
1878-79	19,672	78,688

The large increase in the exports during 1873-74, 1874-75, 1875-76 and 1876-77 may be ascribed chiefly to the completion of the excellent system of roads and wells established by Captain Wood, by which the forests have been made accessible. The decrease during the last two years is probably due to the diminution of the dry timber lying in the forests.

Selection Fellings.

5. The cuttings on Government account have hitherto been arranged in the following manner. In 1863, as the result of an inspection of these forests

* Paragraph 13 of joint memorandum, dated the 1st October 1868, by Mr. D. Brandis and Captain E. S. Wood.

† Paragraph 30 of Annual Forest Report of Oudh for 1876-77; paragraph 40 of Report for 1877-1878, and paragraph 34 of Report for 1878-79.

‡ These figures include also the Bhira (cis-Sárda) sub-division of the Kheri forests.

by myself in company with Mr. Read, the then Conservator, the maximum number of first class sál trees to be felled was fixed at 4,000 per annum.* It was also settled that in no instance should more than one in four first class trees be felled, that no trees should be felled on the edge of a blank or where trees stand far apart; and it was provided that the felling operations should proceed in regular order from west to east, and that the tracts assigned for cutting should be well defined. At the same time it was said (paragraph 19) that "these rules will probably be found to restrict the felling of large trees more than is absolutely requisite for the welfare of the forests; indeed, in many localities where the number of second class trees is very large, it may be desirable to remove the whole of the first class trees, but until more complete experience is gained it is as well to be entirely on the safe side." In accordance with these rules the cuttings were regulated during seven years, from 1861 to 1867; but a much smaller quantity was cut than was prescribed, *viz.*, only 12,000 trees in all, or 1,714 per acre on an average. The difficulty of procuring labour and the insufficient demand at remunerative prices were the chief reasons for the small quantity cut during this period.

* Paragraphs 6 to 20 of memorandum by D. Brandis dated the 23rd June 1863.

6. These arrangements were revised in 1868, and the following is an extract from a joint Memorandum drawn up and submitted to Government on the 1st October 1868 by myself and Captain Wood, who had succeeded Mr. Read as Conservator.

The present plan of operations in the Oudh Forests must of necessity be of a preliminary nature. It comprises two years only, 1868-69 and 1869-70, and relates principally to the operations in the 1st Division; for in the 2nd and 3rd Divisions it does not yet, for various reasons, appear expedient to commence regular felling operations.

In the 1st or Kheri Division, timber has hitherto been felled in the north-east portion of the forests only. Altogether 12,000 trees have here been felled since 1861, but the trees selected were more or less scattered over the forest, and not cut in certain defined localities.

The first question is, what proportion of the mature trees, in girth 6 feet and above, may be removed without interfering with the reproduction of the forest? Some data regarding the proportion of the trees of different classes have been obtained by the forest surveys made in 1863 by Messrs. Brandis and Read, and in 1867 by Captains Wood and Losack. The results of these surveys may be summarized as follows:—

	1863.		1867.				
	Sál.		Sál.		Asna.	Miscellaneous.	Total.
	On 204 acres.	On 10 acres.	On 177 acres.	On 10 acres.	On 10 acres.	On 10 acres.	On 10 acres.
I class, above 6' girth	703	33	524	29	7	2	38
II „ 4'6" „	1,190	58	630	35	12	4	51
III „ 3' „	6,955	340	1,751	98	48	35	181
III „ 1'6" „			3,504	197	72	183	452
Total ...	...	431	...	359	139	224	722

These surveys were made in different parts of the 1st Division; they agree in showing that there is an ample stock of the 2nd and 3rd classes. Another result of Captain Wood's surveys of last season is that the unsound trees which do not yield marketable timber are very numerous, and Captain Wood thinks that nearly two-thirds of the 1st class trees will be left standing, because unfit for removal.

In Dr. Brandis' memorandum on the management of the Oudh Forests, dated the 23rd June 1863, it was proposed that, as a commencement, not more than one in four 1st class trees be felled in any part of the forests, in order to have a sufficient number of trees on the ground for seed and shelter.

With the additional data now obtained, this rule may be modified, and, as an experiment, all sound 1st class trees likely to yield good marketable timber may be felled. This will still leave a considerable proportion of 1st class trees standing, which, together with the 2nd and 3rd class trees, will probably be sufficient to secure a healthy reproduction of the Forests. Indeed, where the number of 2nd class trees is considerable, it may hereafter be considered whether the standard size of the trees to be felled may not be lowered.

Some latitude should, however, be left to the discretion of the officer conducting these operations. Thus, where trees stand far apart and on the edge of the forest, a smaller number only, or no trees at all, should be felled.

With this reservation, we consider it expedient that, by way of experiment, for the next few years all sound 1st class trees that will yield marketable timber be felled in those tracts where felling is going on. It is believed that, besides sál, the timber of two other reserved kinds, asna and haldu, will find a ready sale, and of these two kinds also all 1st class trees that will yield sound and marketable timber should be felled.

The next question is, how shall the annual fellings be limited? The two different methods of effecting this, by either defining the area of the annual fellings, or by limiting the quantity of timber to be felled yearly, were indicated in the memorandum of 1863. In both cases, the length of rotation must be determined, and this will depend on the rate of growth of the trees in the Oudh Forests.

From the data at our disposal in 1863, the following scale of growth had been formed :—

Age 50 years, girth 4′ 6″
„ 80 „ „ 6′ 0″

Captain Wood believes that on an average there are 8 concentric rings on each inch of radius near the centre, and 10 in the outer portion of the tree, and assuming that each ring corresponds to one year's growth, he concludes that the following may be assumed as the average rate in the Oudh Forests :—

Age 65 years, girth 4′ 6″
„ 95 „ „ 6′ 0″

These data give 30 years as the time during which the present stock of mature trees may be removed, so as to allow the 2nd class trees to take their places.

In the memorandum of 1863 it was proposed to increase this time to 40 years, and, considering the great uncertainty which as yet exists concerning the rate of growth of the sál tree, it will be safer to accept this figure.

The removal of all marketable 1st class trees within this period of 40 years might be effected by dividing the forest into 40 compartments of about the same productive power, and restricting the felling operations of each year to one compartment only.

But, as explained in 1863, an arrangement of this kind can only be carried out when a more complete knowledge of the forests shall have been obtained; and until such time the annual felling operations must be limited by quantity, that is, the maximum number of trees to be felled annually must be fixed.

The sál forests in this division cover an area of about 150 square miles, which, at the rate of Captain Wood's surveys (29 sál and 7 asna trees, both 1st class, on 10 acres, or total 2,304 per square mile), may be supposed to contain a growing stock of about 345,600 1st class trees, of which, however, one-third only, or 115,200, is likely to be fit for removal. Distributing this over 40 years, we have 2,880 trees (sál and asna) as the limit of the annual fellings, which, to include haldu (not taken into account in the calculation), may be raised to a total of 2,900 trees.

In 1863, 4,000 was fixed as the limit for sál alone, but at that time one-half only was allowed for losses from unsoundness and other causes, whereas now the loss is assumed at two-thirds.

Since 1861, or during the first seven years of the establishment of the Department, 12,000 trees have been felled, instead of 20,300, the limit fixed by the present estimate.

There has therefore not been any overfelling; but, on the other hand, it does not appear advisable at present to increase the yield on account of the smaller number of trees felled in previous years.

Now as to the locality where timber should be felled during the next two years, it is desirable, first, to take in hand those parts where felling has been commenced, and to clear out all marketable trees of the 1st class, and then close those tracts absolutely against cattle and all ingress and interference, until the young forest is old enough to take care of itself.

A line, 100 feet wide and 15 miles long, has been cleared in a north-westerly direction, from Dudua Ghât on the Soheli river, to the Nepal boundary line near Gwarighât.

This line divides the western part of the forest into two main subdivisions. There has been felling on both sides of the line as far southwards as a line running from Newalkhar to Mussan Kham. On this line felling should now commence, and proceed to the north-west, but it should be limited to the south-west side of the main line mentioned above.

The line where operations are commenced, as well as that where they are closed, should be cleared to a sufficient width, of inflammable matter, and the greatest care should be used to guard against the inroad of fires into the block where felling operations have been completed.

It may be useful early in the season, before the grass is quite dry, to fire a belt all round the block, and all round the edge of the grassy plains.

Next year, 1869-70, the work would be continued where it will be closed this year, and when it has been completed south-west of the main line, the north-east sub-division should be taken in hand, work commencing in the north and proceeding towards the south-east.

As said above, on the outer edge of the forest, and inside along the open grassy plains, a belt of forest should be left untouched, partly to serve as shelter, partly to secure the springing up of seedlings outside the forest. This is important.

On the expiration of the two years for which provision was made by this plan of operations, fellings continued to be made on the principles and within the limits laid down in October 1868. Although the maximum amount fixed by the arrangement of 1869 was smaller, the number actually felled under this arrangement was much larger, *viz.*, 3,000 trees. Comparing the numbers sanctioned with the average cuttings, the figures stand as follows:—

	Sanctioned limit.	Actuals.
7 years 1861-62—1867-68	4,000	1,714
11 years 1868-69—1878-79	2,900	3,000

It will be noticed that the main points of the arrangement of 1868 were that all trees above 6 feet in girth yielding marketable timber should be cut in those tracts where felling is going on; that fellings should progress in a regular order, and that any tract in which fellings have been completed should be closed against cattle and fires. It was also provided, in conformity with the arrangements of 1863, that on the outer edge of the forest, and inside along the open grassy plains, a belt of forest should be left untouched, partly to serve as shelter, partly to secure the springing up of seedlings outside the forest.

Improvement fellings.

7. Up to 1870 timber only was sold from this part of the Oudh forests, and it was supposed that nothing but timber could be sold, chiefly sál, with a small proportion of asna and haldu. But in a memorandum* appended to the Report for 1869-70 Captain Wood advocated, in addition to the regular fellings which were to be maintained within the limit fixed, *viz.*, 2,900 trees per annum, large thinnings both of the inferior kinds of trees and of sál, including crooked and hollow trees, so as to give more room to the young crop. These operations he intended should be carried on in the compartments where the selection fellings had been completed, and he proposed that whenever a block had been thoroughly cleared of timber and fuel and the creepers had been cut, such block should be protected against cattle and fires. The fuel Captain Wood hoped to dispose of partly at Lucknow, partly to the Oudh and Rohilkhand Railway.

* Appendix No. X.

In passing orders on the Report for 1869-70, the Government of India expressed approval of the plan proposed; but owing to Captain Wood's absence on leave in Europe from 1870 to 1873, no action was taken in the matter.

8. After his return, Captain Wood submitted in his Report for 1873-74 a plan of entire clearance on limited areas in addition to the important cuttings advocated by him in 1870. It will be best to quote the words of his report.—

The present plan of timber operations is that recommended by the Inspector General of Forests and myself (Appendix to Report for 1867-68) sanctioned by the Chief Commissioner and approved by the Government of India. In this plan only about 3,000 first class trees are felled annually in the Kheri sál forests (Newalkhar and Khairigarh sub-divisions). Our knowledge of the growth of sál was very scanty in those days; the Bahraich and Gonda divisions had been overworked, so it was considered advisable to give them rest.

The evil effect of our present system is that we take out the best first class trees, leaving the crooked and hollow ones to cumber the ground; if they were required for seed they would be usefully retained, but we have plenty of seedlings. These large crooked and hollow trees not only keep the young trees, of which there are plenty, from coming up, by depriving them of vertical light, but their wide-spreading roots absorb most of the nourishment.

I have now, I consider, sufficient data to enable me to state that the average growth of sál is $\frac{1}{8}$th of an inch of radius annually, so that the time required for a second class tree to become a first class is fourteen years (or under twenty for safety's sake), so that we could, if we carried on the old system of selection, go on a rotation of twenty years instead of forty, which we are now doing.

Class.	Girth.	Radius.	Age or number of rings.
4th class ...	1′ 6″	2·86″	14·30
3rd „ ...	3′	5·72″	28·65
2nd „ ...	4′ 6″	8·60″	43·30
1st „ ...	6′	11·46″	57·30

It will be seen in Appendix No. VII of my Report of 1869-70 that I gave the measurement of fifty trees, and also that in Appendix No. X of the report for the same year, I recommended a new system of timber operations; but in my absence no notice was taken of the latter,* Captain Stenhouse, the Officiating Conservator, contenting himself, when supplying fuel, with only taking out dead trees and branches which the dry-wood contractors did not care about taking out as timber.

* Though approved of by the Government of India in letter No. 293*F*., dated the 6th June 1870, from the Secretary to the Government of India, Public Works Department, to the Chief Commissioner of Oudh.

I have noticed that where lines fifty and a hundred feet broad were cut through the sál forests to divide the forest into blocks in 1868 and following years, the central fifteen feet only being kept clear for traffic, the young sál trees which have sprung up on the parts cut over are much better than those which are mixed up with the large trees.

In the Charda forest (section V, Bahraich division), which till 1866 was in the possession of the Maharajah of Bulrampur, and in which most of the old trees were cut out or killed and the young ones cut over for domestic purposes, we have a finer shew of young sál trees for its size (about ten square-miles) than in any other forest; indeed, Captain Stenhouse thought that we should soon require to commence thinning operations.

Also in the Ramgarh grant, where almost every sál sapling was cut over for sale, being near the Fyzabad market, since it has had rest under the Forest Department some four years, there are sál trees of from 15 to 21 feet high or more.

In the Bhira fuel reserves large spaces were cleared for cultivation; but it has been found almost impossible to eradicate the sál tree.

Lieutenant-Colonel Pearson, Conservator of Forests, North-Western Provinces, and Officiating Inspector General of Forests, in Chapter V† of his Report on the Kumaun and Garhwal forests for 1870-71, has given his experience regarding the growth and proper treatment of sál forests, which in a great way corresponds with mine; but I do not share with him the fear (there may be some difference between our respective forests) that the grass and scrub will choke the young seedlings (of course if this grass and scrub is fired, the seedlings are destroyed); for our sál forests are gaining on the grass phántás, and would gain very much more if it were not for the fires which almost annually burn up the young seedlings in the Bahraich division, where, owing to the grazing and fires, in some parts there are hardly any seedlings; it is only necessary to surround a patch of ground without seedlings for a year or two with a thorn fence and keep out cattle and fires, and the grass and seedlings come up in abundance.‡

† Appendix No. I.

Where sál is indigenous to the soil it holds its own against all its enemies; it only wants protection from them to thrive well; it wants no careful tending like many other trees.

Sál has another great advantage, that, whereas it shoots freely from small roots, it does not do so from the stumps of large trees.

From my experience of the present stock of even sound trees, I consider few have been maiden trees, *i.e.*, have come from seedlings (proper) direct, but have been kept down by fires or other causes, and when their roots have been firmly established they have shot ahead and overcome the difficulties surrounding them. I am of opinion that for the *real regeneration* of the forests, where there is a good stock of seedlings, everything should be cut over flush with the ground and allowed to start afresh, cattle and fires being kept out at almost any cost, so that the new crop may grow up sound at heart. The covering to the ground would be much greater from this young growth than under the present system.

This system of entire clearance in some parts, and the system advocated in Appendix No. X of the report for 1869-70 (*viz.*, the cutting out of trees that will not apparently make good logs) in others, is part of the plan that I have referred to in paragraph 8 of this report.

The blocks in which these operations take place will necessarily be small at first, and consequently can be guarded from fires and cattle, whereas the protection of extensive tracts under present circumstances is almost impossible.

Our present system, that of selecting, was one necessitated by financial reasons and our small acquaintance with the growth of sál, and is one by which the growth of the forest is *not* improved. The plan of 1869-70 is one of improvement, that of 1874-75 one of regeneration of sound trees.

‡ This was tried on about 4 acres—section VI.

In reviewing this plan, the Government of India said as follows:—

The Conservator of Forests mentions a system of entire clearances in the sál forests which he recommends should be substituted for the present system of thinning out a proportion of the marketable trees. Under this system he anticipates a considerably increased yield in material, but he justly adds that the blocks thus cleared must be guarded from fires and cattle. Under existing conditions it may be practicable to fence in small areas, and thus to exclude fires and cattle. It is not, however, the cuttings of one year only, but of all successive years, which must be protected until the cover overhead is so dense that comparatively little damage is done by the fires. And if it is intended to effect the improvement of the soil by the formation of leaf-mould, then fires must be excluded always.

In 1874-75 Captain Wood commenced these improvement cuttings on the plan proposed by him in 1874. The account of the operation will best be given in his own words:—

The usual fellings on the selection plan took place as usual, but were done in much less time than formerly, the whole of the trees having been felled in the month of January.

I also tried what could be done on a small scale with the plan I recommended, *viz.*, that of improvement, and cut over two compartments of about 40 acres each. I selected a place near Dudua, so that the working might be under my own or Mr. Dodsworth's supervision.

The first of these compartments (40 acres) is situated between the main Gwarighat line and the Suthiana fire path, and an eight foot fire path running at right angles to the former line; the second compartment (42 acres) adjoins it, and is bounded by the Suthiana fire path, the Newra junction line and a fire path running at right angles to the Gwarighat line. This site of operations has also the advantage of being near the Newra junction on the river Soheli, where a depôt has been formed, and to which scantlings and fuel can be carted cheaply for conveyance by boats down the Soheli to Bahramghat.

Almost all the miscellaneous trees were cut out, as were all crooked, damaged and unsound sál, leaving for seed the large sál trees that would improve, and also all the young uninjured sál trees.

The outturn was 8,331·13 cubic feet of sawn timber, and about 125,000 maunds of firewood; this gives about 100 cubic feet of sawn sál timber and 1,500 maunds of firewood per acre of stuff over three inches diameter. These results were from what I consider indifferent forest.

The ground looked rather bare in March, many seedlings having been trampled down during the felling, sawing and carting operations; but in April 1875 the ground seemed well covered, as new shoots had come up, and many seedlings which were kept down by the former shade had a chance of development.

Our great difficulty now is to get a market for our firewood, the Railway Company having declined to receive even the balance of the 500,000 maunds due to them, *viz.*, 204,440½ maunds, at Rs. 19 per 100 maunds: the contract was up to the end of March 1874, and the Railway Company has made arrangements to burn coal, so we cannot press the matter; we are therefore turning the firewood that remains in the forest into charcoal, which will pay. I expect to land it in Lucknow at Rs. 58 per 100 maunds, and sell it at Rs. 76, making a profit of Rs. 18 per 100 maunds of charcoal, or Rs. 4-8-0 per 100 maunds of wood: out of the profit we have to charge wear and tear of boats; but at present I am not certain of a market for a large quantity, though when our first consignment arrives, I hope to be able to make arrangements with the Superintendent, Locomotive Department, Oudh and Rohilkhand Railway, at Lucknow, and also with the Executive Engineer, Military Works, there. I hope also to be able to make arrangements for firewood with the Commissariat at Lucknow and Cawnpore, and also with Executive officers of the Department of Public Works for brick-burning.

On this report the Government of India made the following remarks:—

It is understood from the report that everything was cut excepting saplings and young trees of sál and a number of larger trees for seed, and that the outturn per acre was 100 cubic feet of sawn timber, and about 1,500 maunds of firewood. The sawn timber, Captain Wood calculates, should clear Rs. 100 per acre, but the firewood is not at present likely to sell. If, however, as explained by the Conservator, the firewood is merely put out of the way of the growing young trees instead of being carted away, the cost of the clearance will be about Rs. 3 per 100 maunds, or Rs. 45 to Rs. 50 per acre, which will reduce the profits derived from the sawn timber to from Rs. 55 to Rs. 50 per acre. Captain Wood, however, hopes to dispose of part of the outturn in the shape of charcoal, which, if sold, will, he expects, realize an additional sum of Rs. 60 or more per acre.

Several questions of detail are connected with this subject, into which His Excellency in Council does not deem it necessary here to enter, such as the future cost of these operations and the increased risk of fire by the accumulation of large masses of dry wood in the vicinity of the clearings. But if the Conservator finds his calculations confirmed by further experience, there will, in the opinion of His Excellency in Council, be no objection to his continuing the experiment, in case you should deem its continuance expedient. It will, however,

probably suffice to take in hand annually an area not greater than 50 to 100 acres in extent, and it is desirable that the areas cut over should be continuous. The object of the experiment will be to ascertain the amounts expended on and realized from these operations, and the success which will attend the regeneration of the forest treated in this manner; but the exclusion of fires from the areas cut over is obviously an essential condition of success. I am to suggest that a special report on the condition of each year's cuttings and on the receipts and charges on account of these operations be recorded in each year's report.

It appears evident from what is recorded in the report under review that the main obstacle at the present time to a profitable management of the Oudh forests is the competition of the timber from Nepal, which is larger and more plentiful than that of the Oudh forests. I am, however, to suggest that, as long as this competition lasts, no harm, but on the contrary great advantage, may result from curtailing the annual "selection cuttings" and reducing the quantity of timber brought to market; and the experimental cuttings under the "improvement" system will make it possible to reduce the number of trees felled under the present system of selection.

9. The import of timber from Nepal had been slack for some time, but increased in 1874; hence there was less demand for the timber from the Oudh forests; prices went down, and the revenue diminished.

The surplus revenue from timber operations for the whole of the Oudh forests during the five years from 1872-73 to 1876-77 was as follows:—

	Rs.
1872-73	55,154
1873-74	48,361
1874-75	5,069
1875-76	6,362
1876-77	3,008

10. In his report for 1875-76, the Conservator stated (paragraphs 10 and 11) that owing to the low prices he could not make much, if anything, out of the improvement fellings, and that owing to the want of officers he had to confine himself to a very small area.

Upon this the Government of India observed as follows:—

Captain Wood's report is not satisfactory. You have justly noticed the insufficient information given regarding the system of cuttings in the Kheri Division, which was first recommended by Captain Wood in his report for 1873-74, and termed by him "improvement cuttings." In the orders on the report for 1874-75, the Government of India discussed the subject in detail, and said that the object of this experiment would be to ascertain the amounts expended on and realised from these operations, and suggested the submission of a special report on each year's cuttings and on the receipts and charges on account of these operations.

The Conservator has contented himself with saying that a very small portion of work was carried on; that the stock from these cuttings gets mixed up with the other stock; and that it is difficult to give an exact detail of expenditure and income.

But, as pointed out by you, the orders of the Government of India specifically required an account of the receipts and charges of these operations, and the Conservator has neglected to attend to these orders.

Very probably the fuel and inferior timber which forms the bulk of the material obtained from these cuttings was not saleable under present circumstances at remunerative rates, but this should have been explained in detail, and an effort should under all circumstances have been made to keep a separate account of the materials obtained from these cuttings.

The Conservator should be informed that to commence experiments of this class without keeping an accurate record of their results can only lead to waste of time and money. A special report should now be submitted, showing the area cut over each year, and giving an approximate statement of the material obtained.

And regarding the selection fellings, the following remarks were made:—

The question whether the annual selection cuttings, which furnish the main portion of the timber exported from the Oudh forests by Government agency, should not be curtailed was discussed fully in the letter from this office No. 280, dated the 29th March last. The Government of India had suggested that these operations might advantageously be curtailed, but this suggestion was withdrawn on Captain Wood's statement that there was a reasonable prospect of a steady demand at remunerative rates for public buildings and for other purposes. So much is clear that, during the two years that have passed, these operations have not been remunerative, and as regards the future, no facts are recorded in the present report which justify the expectation of a more favourable result.

It will, however, be advisable not to form any hasty conclusions on this question, and under all circumstances it seems right to continue during a sufficient time the operations which Captain Wood has set on foot at Bahramghât, to improve the sale of the Oudh

timber by sawing it up into scantlings. The result of these operations will be awaited before passing final orders on the subject of curtailing the annual selection cuttings. Hitherto the work of the saw-mill at Bahramghât has not been profitable; and should this continue so, as Captain Wood himself seems now to anticipate, and should no other mode of disposing of the produce of the Government timber operations in the Oudh forests at remunerative rates be discovered, then it will have to be seriously considered whether the annual selection cuttings should not considerably be curtailed. From paragraph 13 of the report it is gathered that, owing to the good system of roads and wells constructed by the Conservator, and the clearing of the Soheli river effected by him, the outturn of dead and fallen timber removed by purchasers from the forests has increased, and may be expected further to increase. During the year under review it is observed that Rs. 1,26,000 were realized from wood and timber removed by purchasers; this, in fact, seems at present to be the chief source of surplus revenue from the Oudh forests.

It is premature at present to form any final opinion on this subject; but should you, after further experience, recommend a considerable reduction of the present departmental timber operations, there seems good reason to expect that the other sources of revenue will maintain a surplus equal to the present moderate average.

The great advantage of curtailing the present timber operations would be that the time and energies of the staff might then be devoted exclusively to works of improvement. In this latter respect not much progress is reported. It is satisfactory that protection was continued in the blocks which had been protected from fire last year, but no extension has been attempted, and the sissoo plantation in the Bahraich district has been burnt.

In 1876-77 no regular improvement fellings were made, the reason assigned by the Conservator being that no officer could be spared for the work.

In his report for 1877-78, the Conservator stated (paragraph 35) that the improvement fellings could not be continued, but that the young growth in the compartments where the improvement cuttings of 1874-75 had been made was most satisfactory.

In 1878-79 no improvement fellings were made.

This closes the history of the improvement fellings, as far as recorded. They were announced with great emphasis as an important improvement in the working of the forests, and they were carried out on 82 acres in 1874-75. Want of officers, the scarcity of labour and the difficulty of disposing of the wood put a stop to these operations in this part of the Oudh forests. In the Bhira sub-division a small area was cut over in 1875-76, but the young growth is reported to have suffered from frost, and nothing has since been reported regarding the continuance of the operations in that sub-division.

Annual fires.

11. The selection fellings have been carried on regularly, but in one essential point the plan laid down for regulating them has not been adhered to. Paragraph 15 of the memorandum of 1st October 1868 distinctly provided that the greatest care should be used to guard against the inroad of fires into the block where felling operations had been completed. And in his memorandum of 1870, which contained Captain Wood's proposals for cutting out unsound, crooked and small trees in addition to those cut in the ordinary selection fellings, the greatest stress was justly laid upon the exclusion of fires from the blocks in which operations had been completed. But what has been done in this respect? The area of the sál forests trans-Sarda is reported to be 115,200 acres. Of this area, only 15,360 acres near Dudua have been protected since 1872, and even this small area was burnt in May 1879, with the exception of 3,420 acres, which fortunately included the 82 acres cut over in 1875.

12. Now where, as in this case, a forest is burnt annually, the only sound policy is to restrict cuttings as much as possible. Captain Wood knows as well as any one else that the difficulty does not consist in the large savannahs outside the forests and enclosed within them. These can be fired early in the season before the grass in the forests is dry enough to burn, and these large savannahs are, I trust, always fired early in the season in the trans-Sarda forests of Kheri. The difficulty chiefly consists in the numberless smaller and larger patches of high grass scattered all over the forests, and in the grass growing under the trees where the forest is not completely stocked.

The sooner this grass is killed out the better for fire protection, and the tall grass can only be killed out by increasing the cover over-head or by excluding fires.

Another difficulty consists in the dry wood on the ground, which increases the violence of the flames. This dry wood in the forests is increased by cuttings whenever the tops and branches of trees cannot be utilized. It may not be possible, at the present time, largely to increase the fire protected area, but whenever the time comes to make real progress in fire protection, such progress will be greatly facilitated by a denser cover over-head if the forest is better stocked, and this can, under existing circumstances, and while annual fires continue, only be attained by restricting cuttings to the utmost. When fires are excluded, not only do the larger trees develop more vigorously and their foliage get more dense, but it is chiefly the young trees which profit; they grow up in thick clumps close together, and the grass is killed out.

All these considerations are well known to Captain Wood, for we have many times discussed them on the spot in the forests. The practical result is this, that in forests which are protected from fire, cuttings and thinnings may be made freely to the full extent of the capability of the forest, while in a forest which is not thus protected the only safe plan is to cut as sparingly as possible.

In forests which are fired annually, cuttings must be restricted.

13. These considerations will explain the observations made by the Government of India* in reply to a remark submitted by the Government of the North-Western Provinces and Oudh in May 1878, to the effect that the plan of operations under which the Kheri forests are worked did not provide for sufficiently extensive fellings. The Government of India replied as follows:—

* No. 559F., dated 31st May 1878.

It appears from the annual reports that, with the exception of very small areas, the whole of the Oudh Government forests are grazed over by large herds of cattle, and are consequently, excepting those small areas mentioned, burnt over regularly every year. Under these circumstances the regeneration of the forest by young growth must necessarily be extremely precarious and imperfect; and as long as this state of things continues, the only safe course appears to be to cut as little timber as possible. Instead, therefore, of increasing cuttings, the question deserves serious consideration whether the annual cuttings should not be curtailed until some arrangement has been made whereby a considerable portion of the forests may be protected against cattle and fires. From paragraph 3 of the letter from the Chief Commissioner of Oudh, No. 465, dated the 14th February 1876, it appears that, under existing arrangements, some 2,000 sál, asna and haldu trees on an average are cut annually; with reference to the preceding remarks it seems best for the present, and until the question of grazing and fire protection has been settled, to reduce this number; and it is suggested that the number of trees of these kinds to be cut annually in the Oudh forests be fixed at 2,000.

In forests protected from fire, cuttings may be extended.

14. In a forest protected against fire, Captain Wood's arguments apply to the full extent. If we have a crop of saplings or seedlings on the ground, or have good reason to expect that if light is given a complete crop of seedlings and coppice shoots will come up, then by all means cut out the old and irregularly shaped trees and all trees that will not fit into the future crop. The same opinion is expressed by Captain Wood in the following words (paragraph 2 of his letter of 27th August 1879) "when large trees have been felled out, of course with the prevention of fires, straighter and sounder trees would be produced in the future." This applies to forests in which old trees preponderate, as in the greater portion of the trans-Sarda Circle. Younger forests, in which poles preponderate, require a somewhat different treatment, and with regard to such forests I would invite attention to paragraphs 79 and 80 of my Report of March 1879 on the management of the forests included in the Forest School Circle of the North-Western Provinces.

Net Revenue from Government timber operations.

15. I have said that in tracts which are fired annually, the condition of the forest cannot as a rule be improved by cuttings. But we must have timber

for the market, and we must have revenue to meet the expense of forest administration. Hence it is clear that some cuttings must be made. But as far as is compatible with these objects, cuttings in forests not protected against fire should be restricted as much as possible.

One argument commonly used in favour of increased fellings is that they will considerably increase the revenue. The following statement shows the fallacy of this idea as regards the last 10 years in Oudh. The result of this statement is that the total surplus during the 10 years in question on account of Government timber operations has been Rs. 156,896. The value of the stock in hand on the 1st April 1869 was Rs. 76,324, and on the 31st March 1879 it amounted to Rs. 1,90,560, the difference being Rs. 1,14,236. The outstandings on account of timber sales and excess payments to contractors compensate each other.

Statement showing the Receipts and Charges of the Forest Department in Oudh during the 10 years 1869-70 to 1878-79.

Years.	Departmental Timber Operations.			Other Revenue.			Formation, protection and improvement of Forests.
	Receipts. — I.	Charges. — AI, ½ of AVI, ⅓ of AIX, ⅓ of B.	Surplus.	Receipts. — II, III and V.	Charges. — AII, AIII, ⅓ of AIX, ⅓ of B.	Surplus.	Charges. — ½ of AVI, AVII, AVIII, ⅓ of AIX, ⅓ of B.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1869-70 ...	24,220	52,306	Def. 28,086	82,602	14,307	68,295	38,555
1870-71 ...	2,704	53,164	Def. 50,460	57,477	16,029	41,448	30,798
1871-72 ...	49,015	68,810	Def. 19,795	88,752	18,487	70,265	39,384
1872-73 ...	1,36,610	81,456	55,154	1,59,648	24,344	1,35,304	37,620
1873-74 ...	1,56,682	1,08,321	48,361	1,46,499	19,905	1,26,594	71,208
1874-75 ...	1,34,224	1,29,155	5,069	1,48,187	19,979	1,23,208	55,693
1875-76 ...	1,31,954	1,25,592	6,362	1,62,704	27,340	1,35,364	45,483
1876-77 ...	1,43,970	1,40,962	3,008	2,45,043	33,204	2,11,839	58,443
1877-78 ...	2,15,965	1,16,472	99,493	1,86,987	27,885	1,59,102	61,590
1878-79 ...	1,78,497	1,40,707	37,790	1,28,073	29,949	98,124	68,946
Total ...	11,73,841	10,16,945	1,56,896	14,00,972	2,31,429	11,69,543	5,07,720

Surplus from "Departmental Timber Operations"	Rs.	1,56,896
Surplus from "Other Revenue"	„	11,69,543
Total Surplus ...	Rs.	13,26,439
Deduct Charges for "formation, protection and improvement of Forests" ...	„	5,07,720
Net Surplus ...	Rs.	8,18,719

If to the cash surplus is added the increased value of stock, the total net revenue derived from these operations during the last 10 years has been Rs. 2,71,131, which is at the rate of Rs. 27,113 a year. Considering that the annual outlay has exceeded Rs. 1,00,000, this is a most insignificant result.

The gross and net revenue on account of the two great branches of revenue during the last ten years have been as follows :—

	Government Timber Operations.	Other Revenue.
Gross Revenue	11,73,841	14,00,972
Net Revenue	2,71,131	11,69,543

This is after adding the increased value of stock.

It is to be hoped that by the aid of the Bahramghât Saw Mills matters will improve; but as long as the net revenue of the Government timber operations is so insignificant, it is clear that, unless fires can be excluded from the forests, no important object would be gained by largely increasing these cuttings.

The following remarks will explain the statement. The Oudh Forests from 1869-70 to 1876-77 comprised the Kheri, Bahraich and Gonda Divisions. Commencing with 1877-78 the Bareilly and Gorakhpur Divisions were added.

The charges have been allotted to the three great heads in accordance with the arrangement given in paragraph 98 of the Oudh Report for 1878-79. According to this arrangement the charges on account of Government timber operations comprise besides AI (timber expenses), half of AVI (live and dead stock), one-third of AIX (miscellaneous), and one-third of B (Establishments).

The charges on account of other revenue comprise AII (timber removed by purchasers) and AIII (confiscated drift and waif wood), and one-third of AIX (miscellaneous) and B (Establishments).

The charges on account of the protection and improvement of the forests comprise the remainder of the charges under A "Conservancy and Works." and one third of B "Establishments."

The limit of cuttings must depend upon the extension of fire protection.

16. So much is evident that for the sake of net revenue derived from Government timber operations it is not worth while to interfere with the gradual though slow improvement of the forests, which certainly is the result of restricted cuttings in forests not protected from fire. The insignificant additional net revenue which under existing circumstances might be realised by increased timber operations is more than counterbalanced by the advantage of preparing the way for fire protection, when the time comes to take more vigourous action in that direction than has been done hitherto.

Nor is there any evidence of a demand for timber from the Oudh forests so pressing as to justify a departure from the policy here sketched.

17. It should, however, be clearly understood that, in the event of any large demands for timber arising, or in the event of the net revenue from timber operations increasing considerably, no objection need be raised to a large increase of the annual cuttings. Thus, when the late demand for wood for opium boxes at Patna arose, the Government of India did not hesitate to suggest that the annual cuttings should be increased in order to meet that demand.

It will be explained further on that our knowledge of the growing stock and the rate of growth of the Oudh forests is as yet too imperfect to admit of a rigid limitation of the quantity of timber to be cut annually. Whatever limitation may be fixed at present must to a great extent be arbitrary, and up to a certain extent the limit must be elastic, admitting of an increase, in case any great demand or considerations of revenue should render such increase desirable. This is justified in the case of forests so extensive and hitherto so sparingly worked as the trans-Sarda forests of the Kheri Division. The main point to be kept in view is that forests like these should be worked as sparingly as possible, until they can be protected against fire.

Cuttings how to be regulated.

18. As regards the method to be followed in regulating these cuttings, it is possible that some timber may be cut in blocks which may be assigned to villages for the supply of wood and pasture. In such blocks cuttings would be regulated by principles different from those which must regulate cuttings in portions of the forests intended to be permanently maintained as such. The following remarks relate only to those portions which it is intended to maintain permanently.

The discontinuance of the improvement cuttings commenced by the Conservator in 1874-75 is, I think, to be regretted, and they should be resumed and continued every year on a limited scale as far as demand and financial considerations may admit, until a definite result has been obtained; an accurate and detailed record being kept of the annual outturn, the trees left standing and the outlay and receipts from these operations. The record should also contain a continuous account of all noteworthy occurrences, such as the thinning out of the young growth of other trees when it threatens to interfere with young sál. It will of course be understood that continuous protection against fire of the compartments cut over is essential.

As regards the selection fellings there can be no objection to cutting all old and all unsound or badly grown trees of whatever kind they may be, pro-

vided fires are kept out afterwards. If the places where such cuttings have been made cannot be protected against fire, then it seems to me much better to continue the present system of selection fellings.

Growing stock.

19. The preceding remarks will have explained that in the present arrangement of fellings in the trans-Sarda portion of the Kheri forests, the question to what extent these fellings might be increased depends much more upon the extension of fire protection than upon a consideration of the growing stock of the different classes and the rate of growth of the sál trees.

Nevertheless, it will be useful on the present occasion to take a brief review of our knowledge on this subject, and to indicate what remains to be done in this respect. The following statement gives a summary of the valuation surveys made up to date.

Abstract of Valuation Surveys made in the trans-Sarda Forests, Kheri Division, Oudh.

Particulars.	Sál : Girth of trees.				Reserved trees:* Girth of trees.				Miscellaneous : Girth of trees.				Remarks.
	Over 6.'	Over 4½.'	Over 3.'	Over 1½.'	Over 6.'	Over 4½.'	Over 3.'	Over 1½.'	Over 6.'	Over 4½.'	Over 3.'	Over 1½'	
1. Dr. Brandis and Mr. Read, in 1863, on 204 acres.	703	1,190	6955		...	...	...	...	...	...	...	...	Paragraph 6 of Memorandum dated 23rd June 1863.
2. Trees standing on lines cut in 1867-68 on 177·7 acres.	524	630	1,751	3,504	116	207	853	1,263	44	75	649	3,239	Report, 1867-68, Appendix No. II.
3. Trees standing on lines cut in 1868-69 on 156·0 acres.	771	1,100	1,851	8,871	214	402	560	1,303	81	360	1,850	10,470	Report, 1868-69, Appendix No. III.
4. Trees standing on lines cut in 1869-70 on 210·31 acres.	692	1,175	2,196	4,989	143	172	470	820	22	71	732	8,080	Report, 1869-70, Appendix No. VI.
5. Trees standing on lines cut in 1870-71 on 43·39 acres.	155	208	383	852	12	33	76	115	6	28	112	957	Report, 1870-71, Appendix No. III.
Total of 2 to 5 on 587·40 acres.	2,142	3,113	6,181	18,246	485	814	1,959	3,501	153	534	3,343	22,746	

* Ebony (*Diospyros Melanoxylon*), dhau (*Anogeissus latifolia*), asna (*Terminalia tomentosa*) haldu (*Adina cordifolia*). Sisso, toon and khair, are also reserved trees, but these are not found in the sál forests.

The majority of these surveys were made on lines 100 or 50 feet wide, which were cut through these forests in order to make them accessible, to facilitate fire protection and to divide them into blocks and compartments; and on a portion of these areas surveyed between 1867 and 1871 selection fellings had already been made.

Summary of results.

20. The results per acre are as follows:—

	Survey No. 1.	Survey Nos. 2 to 5.			
	Sál.	Sál.	Reserved trees.	Miscellaneous.	Total.
First class, in girth 6 feet and upwards	3·45	3·64	0·82	0·26	4·72
Second „ 4′ 6″ to 6 feet ...	5·83	5·29	1·38	0·90	7·57
Third „ „ 3′ to 4′ 6″	34·09	10·52	3·33	5·69	19·54
Fourth „ „ 1′ 6″ to 3′		31·06	5·96	38·74	75·76
Total ...	43·37	50·51	11·49	45·59	107·59

These figures exhibit two very satisfactory features,—the preponderance of sál over trees of the other kinds, and the large proportion of the sál trees of the younger classes. In a portion of the forests (surveys of 1868-69 and 1869-70) the miscellaneous trees of the smaller classes, between 1′ 6″ and 3′ in girth, were more numerous than sál But, as a rule, sál has the upper hand; and if protection from fire were ensured, all first class sál trees might be cut out with great advantage as far as the condition of the forests is concerned, subject only to the consideration of leaving trees for seed where necessary and of providing an annual supply of timber. At the same time, it will be noticed that the forests are not very densely stocked. An average of 107 trees of all classes per acre down to saplings 18″ in girth, of which only 12 trees are in girth 4′ 6″ and upwards, does not cover the ground. A better stocked forest, with double the number of trees, would contain less grass and would be more easily protected from fire.

Future Valuation Surveys.

21. Similar valuation surveys should be made whenever fresh lines are cut through the forest, and it will be convenient to maintain the same size classes. If it should be desired to facilitate the operation and to save time, the trees of the third and fourth classes might be counted together.

We must, however, guard against basing any conclusions regarding the growing stock in the whole of these forests upon the valuation of so small an area, which is only 0·7 per cent. of the total estimated area of sál-producing forest (115,200 acres). When fire protection of that portion of the trans-Sarda forests of the Kheri Division which it is proposed to maintain and to improve has been secured, these forests should be worked to the full extent of their capabilities, and then the first step must be the valuation of a much larger area than has hitherto been examined. Whether the working plan which will then be framed will assign a certain number of compartments for each year's cuttings, or whether the maximum number of trees that may be cut annually will be fixed, an estimate of the growing stock of the different classes must in the first instance be framed.

At the same time it will be necessary to divide these forests into blocks and compartments, and to draw up a brief descriptive account of each compartment. The character of these forests being exceedingly uniform, these descriptive accounts may be very brief; but they should contain an approximate estimate of the area in each compartment stocked with savannah, with sál and with other forest. They should also give a summary of the growing stock of different sizes in the compartment as determined by the valuation surveys made in it.

Rate of growth.

22. The only tree regarding the rate of growth of which we need concern ourselves in the present case is sál. The other kinds which are associated with sâl in these forests, though useful as companions, have an exceedingly small value as compared with that of sál, and are not sufficiently numerous to require any special study in this respect, except in so far as it is important

to know whether they grow more rapidly than sál or not. Regarding the rate of growth of sál, as of other trees, our present sources of information are of two classes,—the measurement of trees of known age, and the counting of what are supposed to be the annual rings in the wood.

The only known observations of the first class are recorded in the memorandum of June 1863 already quoted, which is printed as an Appendix to the Oudh Forest Report for 1867-68 by Captain Wood. The trees were measured in 1863 at the following places:—

Saharanpur Garden,	age	13	years,	girth	27	inches,	average of 33 trees.
„	„	„	30	„	„	54½	„
„	„	„	35	„	„	79½	„
Calcutta Garden,	„	25	„	„	69	„	

The girth was measured between 5 and 6 feet from the ground.

Concentric rings in sal and structure of the wood.

23. The counting of concentric rings has been attempted at different times and in different forests; but the question whether these concentric rings, which have hitherto been regarded as annual, really correspond to the annual increment of the tree, has not yet been solved in a satisfactory manner.

The structure of sál timber on a transverse section is as follows:—Between numerous prominent medullary rays are seen single lines of pores, sometimes in radial groups of 2—3, which often are filled with resin. The structure of the wood is exceedingly uniform from the centre to the circumference. Numerous concentric lines are visible, but there is no difference in the size and distribution of the pores at the inner and outer edge of the belts within these concentric lines. Nor have I been able to discover that any additional medullary rays take their rise at these supposed annual rings, as is often the case in other woods. Narrow white lines are the only mark by which I am able to distinguish these concentric rings. In old heartwood these lines are sharp and distinct; they are less marked and often invisible in the sapwood. Often a number of these lines are close together, which makes it difficult to fix upon one concentric ring as more prominent and more likely to be an annual ring than the others. These concentric rings are often interrupted and only partly concentric. I have examined hundreds of sections of sál trees in different places and at different times with the same result, *viz.*, that these concentric rings are extremely confusing. In many cases it was not possible at all to recognize a series of rings in a satisfactory manner; in others they could only be read on a portion of the radius; and very often the readings on different radii did not agree. I have found such discrepancies as 56 rings on one and 76 rings on another radius. Under these circumstances, nothing short of the examination of numerous sections of trees of varying but known age can lead to a satisfactory conclusion in this respect, and, unfortunately, hitherto these examinations have not given any uniform results.

Annual rings in Teak.

24. In the case of teak it has been possible to examine sections of trees planted in Burma of different ages up to 20 years; of trees from the Nilambur plantation in Malabar, up to the age of 35 years; and of trees which were planted in the Botanic Garden, Calcutta, in the end of last century, which were 70 years old when blown down by the Great Cyclone of 1864. These examinations have led to the result that in teak the concentric belts, which are marked by larger and more numerous pores in the inner portion, as a rule, correspond each to the growth of one year. In young coppice shoots of teak, a larger number of rings than would correspond to the age of the shoots is sometimes observed. This peculiarity has been noticed in different localities, but it was first brought to public notice by Mr. Fernandez,* who had observed an excess of rings in coppice shoots up to 5 years old in the Punassa Reserve in Nimar.

This remarkable fact requires further enquiry; but, as far as our present knowledge goes, we have no reason to doubt that in older trees the concentric rings in the wood of teak are annual.

* "Indian Forester," Vol. IV, page 355.

Concentric rings in sal trees of known age.

25. The examination of the wood of young sál trees of known age has not hitherto led to any definite result. The researches are in progress, and it must suffice on the present occasion briefly to enumerate a few facts bearing upon the question. During my last tour through the Oudh Forests in March 1875, I examined a number of saplings in the Charda Forest which had been protected from fire during the two previous hot seasons of 1873 and 1874. The lower part of these saplings, which had grown up under the influence of annual fires, had the bark rough, blackened and fissured, while the upper part of the stem, which had grown up without fires, had a clean and smooth bark. Sections made at the base of the upper or fire-protected portion of the stem, which had grown up since the hot weather of 1872, and were therefore nearly three years old in March 1875, gave no definite conclusion, some sections showing two and others a larger number of rings.

26. Opposite the Dudua Rest-house, three saplings (coppice shoots) were cut on the occasion of my visit in 1875. They had grown up on a spot which had been cut clean over in 1867-68.

The examination of the sections at the foot of the stem gave the following results:—

	1.	2.	3.
Mean diameter, including bark	3·2″	3·″	4·5″
Mean thickness of bark	0·35″	0·3″	0·35
Mean radius of wood	1·25″	1·2″	1·9
Concentric rings	6	6	6
Rings per inch of radius	5	5	3

The saplings were eight years old when cut, and on the assumption that the growth of the two first years was destroyed by fire, the concentric rings would indicate the annual growth of the tree.

27. In 1878, when specimens were collected from all provinces for the Paris Exhibition, Captain Wood sent sections of two young trees to illustrate the rate of growth of the tree. Particulars regarding these trees and their details of measurement will be found in his letter of the 9th January 1878, extracts from which are appended to the present report.

The examination of the sections at the foot of the stem gave the following results, as recorded by Captain Wood:—

	1.	2.
Mean diameter, including bark	7″	6·36″
Mean thickness of bark	0·38″	0·5″
Mean radius of wood	3·13″	2·68″
Concentric rings	15	7
Rings per inch of radius	4·8	2·61

Tree No. 1 was supposed to be 16 or 17 years old, and was 50 feet high. Tree No. 2 was supposed to be 8 years old, and was 31 feet high.

28. In June last Captain Wood sent me sections of two young sál trees cut in 1880. The first of these was standing on a 100 foot clearance which had been cut level with the ground in February and March 1874 along the Nepal boundary line. Since then a dense growth of sál and other trees has grown up together with a good crop of sál seedlings. A sapling was selected at random, and the section, taken between 6 and 15 inches above the ground, gave the following results:—

Mean diameter, including bark	4″
Thickness of bark	0·5″
Mean radius of wood	1·5″
Concentric rings	5
Rings per inch of radius	3

The age of the tree was six years, but besides the five concentric lines, which are more distinct than the others, there are numerous other lines, making the reading of the annual rings a matter of great uncertainty.

Regarding the other specimen Captain Wood writes as follows:—

The specimen was growing near Dudua; the original shoots had been destroyed, and a side shoot had taken its place. During Christmas week, 1873, since my return from furlough to

England, I had the old stump cut away and made smooth, with a slope outwards to carry off the rain water. It will be noticed that the wound had entirely closed over, and at the upper part of the stem the growth since the first operation can be easily distinguished. I cannot exactly trace the first year's growth, but there appear to be afterwards five well distinguished annual concentric rings with intermediate circles within them. The growth is very rapid, and shows a great deal more than one-fifth of an inch of radius per annum. What I particularly want you to see is the inner rings between what I consider the annual spaces.

The examination of this specimen at different points above the standing surface of the old stump, which is distinctly seen on a longitudinal section, gave no definite result. The concentric lines are exceedingly numerous, some close together, others further apart, but none are sufficiently marked so that they could be taken as annual rings. Three inches above the top of the old stump, the diameter with bark is 7·5 inches, and without bark 6 inches. Here 8 or 10 rings are somewhat more marked than the others, but there is no certainty regarding them, and no conclusions can be drawn from this specimen.

29. Within the last few days I have learnt that Captain Bailey, the Conservator of the School Forests, has obtained a section of a sál tree of known age, 28 to 30 years old, and that from this section he hopes to learn to recognize and to count the rings much better than could be done formerly.

There is thus some prospect of progress being made in this direction.

Counting of annual rings.

30. So far regarding the examination of sál trees of known age. It will now be well briefly to review the results hitherto obtained by the counting of what were supposed to be annual rings in different forest districts.

In 1863 the mean of two stumps at the head of the Kotri-dun, Garhwal, elevation 2,500 feet, gave a girth of 8 feet 2 inches with 162 rings, or an average of 16 rings per inch of radius.

Between 1873 and 1877 Mr. Fisher examined the rings on a large number of stumps in different forests in the Darrang, Kamrup and Goalpara Districts of Assam. The details will be found put together on pages 324 and 325 of the "Indian Forester," Vol. IV, and the results are as follows:—

Locality.	No. of Trees.	Rings counted on a length of radius from centre, corresponding to a girth (wood only) of—			
		18″	36″	54″	72″
Kamrup, Pantan (on the hill), 1873	22	30	56	82	115
„ „ (in the plains), 1873	18	32	65	96	126
Darrang, Balipara, 1874	32	38	61	92	116
Goalpara, Sidli, 1875	20	28	52	89	...
„ „ 1876	11	26	51	76	...
„ „ 1877	17	26	51	72	90
Total ...	120	30	56	83	112

These figures show great uniformity in the annual increments in different localities and at different ages. The only marked difference consists in this, that the trees in the Sidli Forest show a somewhat better rate of growth than in the Kamrup and Darrang Districts, which are nearer the eastern limit of sál. This, it must be remembered, is the case, although the climate in the eastern districts is moister than in Goalpara.

31. In 1869, Mr. Forrest examined 50 logs cut in the north-west portion of the Kheri Division of the Oudh forests. The details were published in the Oudh Report for 1869-70, and they are reprinted as an Appendix to Captain Wood's letter of January 1878 at the end of this report. The same uniformity will be noticed in the mean annual increments at different ages, as will be seen from the following figures:—

	Average number of rings per inch of radius.
Centre to 2″	... 4·03
2″ to 4″	... 5·11
4″ to 6″	... 5·31
6″ to 8″	... 5·12

It will also be observed that, while the mean number of rings per inch of radius in the 120 trees examined in Assam was 10, it was only 5 in the trees examined in Oudh.

This is a remarkable fact, for even assuming that the conditions for the development of the trees are less favourable in the Darrang and Kamrup Districts than in Goalpara, there is nothing in the appearance of the trees in the Sidli Forest of the latter district which would justify the belief that the rate of growth is slower than in Oudh.

The consideration of this remarkable fact has led Captain Wood to the supposition that, perhaps in Assam, the tree forms two rings in one year. This hypothesis should not by any means be rejected; on the contrary, the rate of growth of sál in Assam and Oudh should be made the subject of careful researches until the matter is cleared up.

32. A few observations made in the sál forests of the Central Provinces gave a mean between Assam and Oudh.

In 1867 the late Captain Douglas examined 13 stumps in the Bijeraghogarh Forests; their mean girth at 17 inches from the ground was 5 feet 3 inches, and the average number of rings per inch of radius was 6·5. The examination of one stump in the same forests gave Mr. Fernandez 7·2 rings per inch, and subsequent observations in the Banjar Valley Forest, Mandla district, gave a mean of 5 to 8 rings per inch.

Based upon these observations the following scales of growth have from time to time been established:—

	Assam.	Oudh.		
		1863.	1868.	1880.
Second class, girth 4′6″	90	50	65	45
First class „ 6′	120	80	95	60

The figures for 1880 are on the supposition that there are on an average five annual rings in one inch of radius.

Annual measurement of standing trees.

33. It will now be well to submit a few remarks regarding the measures that should be taken to collect data for determining the rate of growth of sál in the Oudh forests. The best plan will be, in those Divisions of the Oudh forests where satisfactory arrangements can be made, to select a sample plot of, say, two-fifths of an acre, or larger if it can be done. On this plot all trees should be cut down, except those which are above 18 inches in girth and are straight, sound and vigorous, whether sál or other kinds. Among the trees and poles left standing, the best should be selected for measurement, and these should, as much as possible, be of different sizes. Some should stand isolated and others close together. All trees selected should be marked between 3 and 6 feet from the ground at a point where the shape of the stem is round and regular. Within these limits there is no object in marking and measuring the trees at the same height from the ground. The point is to measure the stem where it is regular. The best mark is a line of oil paint which must be renewed annually. If this should not remain visible after the monsoon, a small wooden nail (heartwood of Khair or Sandan) should be driven into the bark. All trees selected for measurement should be numbered and registered, and the girth should be measured at three places, *viz.*, at the mark, 6 inches above and 6

inches below the mark, each measurement being separately recorded in the Register. Simultaneously with the girth it will be well, if accurate diameter gauges are available, to measure two diameters at right angles to each other, the diameter gauge being always applied at the same points of the circumference. All these measurements should be recorded separately. I do not propose a large number of plots. On the contrary, I advocate a limited number; for it is essential that the measurements should be made by responsible Officers and with great care.

34. In this manner, within a few years, reliable results regarding the annual increment of trees of different sizes will be obtained, and these measurements should not be limited to sál but should extend to trees of other kinds, such as may be available on the plots. It should be remembered that the annual increment measured in this manner consists of the increment of the wood plus or minus the result of the changes which take place in the bark by the additional layers of the fibre and by throwing off of the outer layers. If r is the radius of wood only, the radius of the entire stem (R) obtained from these measurements will be $R=(r+b)$, b being the thickness of the bark, which is an increasing amount during the earlier ages of the tree, but which remains more or less stationary or varies in an irregular manner after the tree has attained a certain size. The thickness of the bark on trees of different sizes b, b,′ b″ must be determined by observation. The mean width of the annual rings of the wood only (W) will then be—

$$W=\frac{r'-r}{n}=\frac{(R'-b')-(R-b)}{n},$$

n being the number of years intervening between two measurements and R′ and R the mean radius of the stem deduced from two measurements at the same point in different years.

35. These measurements should always be taken in one and the same month, and an important question is, which month should be selected for these measurements. In paragraph 17 of the interesting Report which is appended to the present paper, Captain Wood gives an account of the appearance of the sál tree in the Oudh forests at different seasons. He considers that during January the tree is pretty nearly at rest, though it has all its leaves on, and that this is the month for felling, as the bark comes off easily. In Europe spring is the season when the bark of oaks and other deciduous trees comes off easily, and this is caused by the soft condition of the cambium layer, which separates the bark from the wood. The cambium layer is nothing else but the slimy mass of bark fibres, wood-cells and vessels in their youngest state before they have hardened into wood and bark. And this state of things, when the bark separates readily from the wood, is generally believed to indicate the commencement of the annual growth of wood and bark, which continues during part of the summer season. As regards sál, we have no information whatsoever respecting the season when the formation of wood commences. Obviously the best time for the annual measurements would be the season when the tree is at rest and its diameter or girth undergoes no change. Until we have acquired more knowledge on this subject, the best plan will probably be to measure the trees twice in the year, once in the cold season, say towards the end of December, and once in the hot season, say early in April.

36. So far the measurements to determine the annual increments of trees of different sizes under different conditions. The sample plots upon which the trees selected for measurement stand should also be used to study the question whether the concentric rings in the wood are annual or not. For this purpose I would suggest that five saplings, which generally will be coppice shoots, be cut down every year, and that two sections be examined,—one within the first year's shoot, say 12 inches above the ground, giving the full age of the tree, and the other within the second year's shoot, giving one year less, the beginning of which in young saplings can always be traced on the bark, provided fires are excluded. In subsequent years, when the saplings are older and the commencement of the second year's shoot has become obliterated, it will only be possible to take one section from near the base to give the full age of the tree. The result of the examination of the section should be carefully recorded, including the height of the saplings

cut, the thickness of bark, mean diameter of the wood, and the concentric rings. It may be necessary to make several sections within the first and second year's growth, that which shows the rings best being selected. In order to make sure that only saplings which came up the first year are examined it will obviously be necessary to proceed in regular order, selecting the five saplings to be cut annually near to those of the previous year.

The sections should be marked and preserved for further examination. I would suggest that each sample plot in the Oudh Circle be designated by a letter, and that in addition to this the year when cut and the number of the sapling be stamped upon the sections. When two sections of one tree of different ages are taken they should be distinguished by additional letters. After the periodical measurements of standing trees have been continued sufficiently long they should be felled, and sections should be cut at the three points of measurement. The examination (of the outer part) of these sections may be expected to throw light upon annual rings in the wood of larger trees.

37. It follows as a matter of course that these sample plots must never be burnt. If possible, they should be situated in a block which is regularly protected, but even then additional precautions should be taken by surrounding each plot by a fire path. A continuous journal, containing all observations made on these sample plots, and other noteworthy occurrences, should be maintained. When they have done their duty for determining the annual increment of sál trees of different ages, they may be used as experimental plots for other purposes. During my tour through the Oudh Forests in 1875, I made suggestions of a similar nature to Captain Wood, and I understand from him that he has already made a commencement of annual measurements of standing trees.*

Of saplings young enough to show the commencement of the growth of successive years on the bark, it would be most useful to examine sections of each year's growth with the view of ascertaining whether the concentric rings correspond to the years; but such an examination of sections taken from different parts of the stem can obviously not lead to any definite result in older trees, on the bark of which these marks have been obliterated.

Conclusion.

38. The conclusions of the present report may briefly be thus summarized.

First.—The present outturn in timber from the trans-Sarda forests of the Kheri Division (3,000 trees on an average during the last eleven years) is only a small portion of the timber which these forests might yield if they were protected from fire.

Second.—As long as these forests cannot be protected from fire the best plan is to cut as little as possible in order to decrease the violence of the fires and the injury done by them; and to diminish the high grass, and thus to facilitate fire protection when measures in this direction can be commenced in earnest. But any large demand for timber, and the prospect of a large net revenue from extended timber operations, may justify larger cuttings.

Third.—As regards the plan of working in the forests not protected from fire, selection fellings of all marketable trees must continue on the plan framed in 1868.

In tracts protected from fire, improvement cuttings on the plan commenced in 1874-75 should be steadily continued, a separate account of the financial results being kept.

Fourth.—After fire protection has been established in these forests, they should be worked to the full extent, and the cutting out of the mature timber should then only be regulated by the necessity of leaving trees to shed seed, where young growth is wanting, and by the consideration of maintaining a sufficient annual supply of timber, until the younger classes of trees have attained maturity.

Fifth.—As a preparatory step, valuation surveys should be made when opportunities for doing so present themselves, and the rate of growth in these and other forests of the Oudh Circle should be determined by annual measurements of standing trees. At the same time attempts should be made to determine the annual rings in saplings of known age.

* Since printing the above, the Oudh Report for 1879-80 has been received, with instructions to Divisional Officers for the periodical measurement of trees in sample plots, in a Circular by the Conservator, dated the 10th February 1880.

Appendix I.

Extracts from a report by Captain Wood, Conservator of Forests, Oudh, No. 307, *dated the 9th January* 1878, *regarding specimens of sál sent for the Paris Exhibition of* 1878.

PARA. 9. I now give a particular description of the two young sál trees sent. The tree No. 1 I consider to be good growth, but nothing particularly good, as the trees composing the group of which it formed one were too close together for quick growth.

This tree was among the young trees left in the first compartment of the Dudua Home Block Improvement fellings in 1875. I had noticed it from the road getting sickly and almost dead, and felled it.

You will notice how this diseased tree has been attacked by beetles, in comparison with No. 2, which was healthy when felled. On cutting up the tree into lengths, I noticed a peculiar stain in the heartwood of the tree, particularly in the lower portions; the stains were in rings which curiously did not coincide with the rings of growth.

You know how Dudua is situated with regard to Polia, about 4 miles from it. Before the Forest Department was formed (October 1861), the Deputy Commissioners who had charge of the forests prevented the indiscriminate cutting of sál saplings; but as the Deputy Commissioners hardly had possession of the forests till about the year 1859 or 1860, after the mutiny, the prohibition may be put down as having taken place in the commencement of 1860, or 17 years before the tree was felled. As this tree was one of the largest young straight trees in the vicinity of Dudúa, I cannot help thinking that it has grown since 1860, as anything straight would have been used in the cross pieces in thatches. The rings seem to bear me out in my supposition that the tree is under 17 years old.

10. Tree No. 2 we know the age of. The original tree was cut level with the ground in the spring of 1869: three shoots came up; this was the tallest of the three. The section of the smallest of the three at one foot from the ground is also sent.

11. No. 2 was felled early in 1877, so the tree could not have been more than eight years old. It grew near the well at Dudua, and consequently grew under very advantageous circumstances; the growth is extremely rapid, but what is wanted, I consider, is not to ascertain the actual growth of these two specimens, but to get some rule to go on to distinguish the growth of other trees. Besides the number of trees per acre, I consider the person who has the investigation of the rings should be informed of the circumstances under which the sál tree grows.

* * * * * * *

Note on the General Growth of Sal.

14. I will now give a note on the "General growth of Sál," paragraphs 14 to 18. The number of trees to the acre of different ages and species will be seen from the statement annexed. The surveys have been made all over the forests, but more especially in the Newalkhar Sub-division, *i.e.*, in the north-west part of the Kheri Division. They were made by counting the actual stumps on 100 feet and 50 feet lines which were cut over for block lines, for roads and fire conservancy, and were taken in all parts, so that the exactness of the figures can be relied on. Some parts, of course, have more trees on them than others, and some have more old trees, others more young, but the average is good. When we consider that the mango groves of Oudh carry about 50 mature trees per acre, it will be seen that the trees have plenty of room, 107 trees of various growth (not including trees under $1\frac{1}{2}'$ girth or 6″ diameter) being on the acre. It may be roughly stated that the sál trees of the four classes herein given are the same distance apart as mature mango trees are, with a miscellaneous tree between, or all trees are about 20 feet apart each way.

15. It will be seen from the figures that sál is the chief first class tree to be taken into consideration, very few miscellaneous trees arriving at first class size; neither do the miscellaneous trees attain the same height as sál.

16. The average height of a mature sál forest in Kheri is about 80 to 90 feet. The tree is naturally of a beautiful straight growth, and from outside a forest the young trees from their pyramidal shape look like young fir trees. When grown fairly close, and not damaged by jungle fires, they form beautiful clear stems. The young trees shoot up very rapidly, gaining a height of 50 feet in 20 years after they have once made a fair start; they grow to their full height when about 3rd class trees, after which they fill out.

16*a*. Sál grows on high well drained ground on light soil, and will not stand stagnant water at its roots. It has a very strong tap root which goes down very deep into the soil, which in Oudh is decomposed granite. The fibrous roots run for long distances in the upper and vegetable soil.

17. Commencing the year with January, I think we can say the sál tree is pretty nearly at rest, though having all its leaves on. During the night there are some times heavy frosts which kill down the tops of seedlings; this, however, is more to be noticed where the trees are at the edges of open grass plains, and where they have been weakened by fires. Sometimes I have seen the end twigs of large trees killed by very heavy frost, but this does not happen often. This is our month for felling; the bark now comes off easily. February is much the same as January. Towards the end of February the grass in the open plains is burnt, and it is not till March that the grass will burn in scantily populated forests. The grass, however, in the thick forest will, in many places, burn freely in April and everywhere, except in damp spots where the sál tree will not grow in May. In former times the grass in the sál forests was generally burnt for grazing in March-April. The grass fire is the principal fire, as the grass is of different heights from 6 inches to 6 feet, and even 10 feet or more; the average may be said to be 4 feet or 5 feet where the trees grow. Sometimes a fire sweeps through a forest, only burning half the grass (only such parts as are dry); a second fire will come afterwards, but not be so destructive. The grass fires happen about the time the tree is changing leaf. Sometimes the two grass fires happen before the change of leaf: sometimes one before and one after; sometimes both fires happen after the change of leaf, when of course the tree must be much weakened in throwing out two or three sets of leaves. When the weather commences to get warm in April, the old leaves, which are something like Spanish chestnut leaves, but broader, turn yellow and are forced off by the leaves or flower buds. The tree changes its leaves in about 14 days, hardly ever being bare, more or less according to the weather. A day or two after the leaves fall they are as dry as tinder, and the leaf fires take place. These leaf fires, as they are low down, only damage the young growth indirectly. Tremendous shoots are made by the young growth, at this time. At the end of April the heat is intense and dry, and the pumping action of the tree is hard at work, heavy dews falling at night, except in abnormal years, when for a few days the hot winds are blowing day and night. This dry heat lasts till about the 15th or 30th June (sometimes the rain does not fall till August), when everything changes, and for three or four months there is constant rain and the air is saturated with moisture. The weather gradually gets colder and drier in October; in November, though the days are warm, the nights are cool, and it gets colder to the end of December.

18. Sál is in its prime when 6 feet and over 6 feet in girth at 6 feet from the ground. Its growth is, as I have already stated, naturally straight. The fires make it crooked, destroying the leading shoot, a side shoot taking its place. This is generally the case when it is young; but as it gets older, nature repairs it in a wonderful way in the outside layers, and the bole becomes straight and sound looking, though it may be very bad within.

19. Now I consider that there are two growths—the hot dry weather growth, and the hot wet weather growth, a new start being made as soon as the rain commences. When one considers that the heavy rains either take down

into the light porous soil the ashes of the leaves and grass or the juice of decomposed leaves and grass, there must be a large amount of nourishment available for the fibrous roots to feed upon.

20. When the sál tree flowers, it does not do so annually; it generally flowers to excess, there being hardly any leaves till the seed has fallen at the commencement of the rains. This tends to confirm me in my opinion of the rain growth mentioned above.

21. Now can it be the case that in Oudh, with our counting the yearly rings, we have made five rings to the inch, and Dr. Schlich in counting the rings of logs in Bengal (Bengal has a much more rainy climate than Oudh), counted five hot weather growth rings and five rain weather growth to the inch?

22. If this be the case, we can fell double what we are doing at present, and look sooner for the reward of our labours.

23. I cannot but consider that the growth of the sál tree, which has an almost tropical climate, must be more rapid than that of the oak, which has a temperate or frigid climate to grow in, and which has only its leaves for half the time the sál tree has.* Though I regret I cannot fix the age of trees except in lines that have been cut over, yet having been 14 years now in Oudh, I can see the greatest difference in the forests where there is young growth.

* This was written in December 1877. Sir Robert Christison, Honorary Vice President of the Royal Society of England, &c., in a pamphlet on the "exact measurement of trees" of which extracts have been quoted in my instructions noticed in my letter of April 1880, and which pamphlet was written after my paragraph 23 was written, says about the exact measurement:—"And so it may settle the question which has been lately started by some arboriculturalists, whether trees with evergreen foliage make wood during the season when deciduous trees are destitute of leaves." I take sál to be an evergreen to all intents and purposes.

E. W.—2-4-80.

24. I should mention that in felling sál trees near the ground I have seldom seen trees over one foot in diameter throw out coppice shoots, and trees of 1′ 6″ and 2′ diameter never: trees up to 9″ coppice wonderfully; cut a 6″ diameter tree near the ground, and the chances are 100 to 1 that only one straight shoot comes up from one side near the ground; this will make a growth of 6′, 8′ or 10′ in the first year or two, and in less than three years it will be about 15 feet high. Trees of larger growth, if cut off or knocked off at or over six feet from the ground, generally repair themselves in a wonderful way, one or more large leading shoots going straight up.

25. I consider that most of our present mature trees have come up from young coppice shoots, *i.e.*, from trees that have been burnt or cut over when about 6″ diameter, and then they have made rapid growth and got out of the reach of jungle fires.

26. In the measurement of the 50 stumps, I would draw attention to the following figures. On the average I calculate that it takes 4·79 rings to make an inch of radius.

The first two inches of radius from the centre give				4·04	rings per	inch.
„ second	„	„	„	5·21	„	„
„ third	„	„	„	5·31	„	„
„ fourth	„	„	„	5·12	„	„

The first two inches are not far from the average of the No. 1 young sál tree: take the part D which has 6·01 diameter or 3 inch radius, and we find 14 rings; take the same from the average of the 50 stumps and we have—

for 1st	inch	...	...	...	...	... 4·04
„ 2nd	inch	...	...	...	...	... 4·04
„ 3rd	inch	...	...	...	...	... 5·21
					Total	... 13·29

or if my average of 4·79 be taken and multiplied by 3, the number of rings should be 14·37; or take mean of the figures found by the two methods and we have—

$$\begin{array}{r} 14{\cdot}37 \\ 13{\cdot}29 \\ \hline 2 \;\big|\; 27{\cdot}66 \\ 13{\cdot}83 \end{array}$$

which is very near the 14 rings.

It appears that the growth is quick at first, getting slower as the tree is growing in height, and that its rings are larger after the first six inches of radius have been obtained, the average growth of the 8″—10″* inches being again 4·04 (taking a mean by dividing the rings in the 8″—10″ column† by the number of inches over 8″ and between that and 10″;‡ then 81-75‡ inches give 345 rings, or 4·22§ rings to an inch).

* The 5th two inches from the centre.

† Deducting specimens 16 and 27.

E. W.—3-4-80.

‡ In the main radius column.

§ This seems to show that the annual rings are getting thinner as the area of the rings are getting larger.

E. W.—3-4-80.

27. Can the frost, the several jungle fires, both of grass and of leaves, the change from the hot weather to the rainy weather and the flowering cause the rings which lie between the annual growth? These circumstances are ever changing; some years there are no frosts, some years there are no flowers, some years there are several jungle fires, in some there may be only one or none.

If I am right in my supposition that these causes do make rings within the annual rings, will it not be borne out if in garden and planted trees there are fewer marked rings between the rings of annual growth, as they do not suffer so many changes? I would ask, is there any possibility of the trees showing a monthly increase, as I think I have counted in some clear annual rings some 12 or 13 small rings, which may have been caused by the dark and light parts of the months at night?

Appendix II.

MEASUREMENTS TO ASCERTAIN THE AGE OF TREES.

The specimens selected were slabs, planed and oiled, and were taken from trees felled in the north-west portions of the 1st or Khiri Division, Oudh Forests. The rings were counted by Mr. Forrest, Sub-Assistant Conservator, in September 1869.

Number of Logs.	Girth. Inches.	Long Radius. Inches.	Short Radius. Inches.	Mean Radius Inches.	0—2".	2"—4".	4"—5".	6"—8".	8"—10"	10"—12"	Average rings or years per inch of Radius.	1st Counting.	2nd Counting	3rd Counting.	4th Counting.	5th Counting.	Total	½.
1	62	12½	8	9½	10	8	13	12	8		5 45	51	57	50	48	53	259	51⅘
2	63	11½	8	10	12	11	8	11	7		5 00	49	52	49	51	49	250	50
3	62	10½	9	9¾	7	11	13	12	9		5 37	52	56	55	50	49	262	52⅖
4	62	11½	8½	9¾	7	12	10	7	8		4 54	44	48	46	41	43	222	44⅘
5	59¾	12	7	9½	7	13	11	9	8		5 28	48	49	54	50	50	251	50⅕
6	56½	10	7	9	5	7	10	11	9		4 93	42	46	50	45	39	222	44⅖
7	58	13½	5¾	8¼	3	11	10	11	6		5 00	41	38	45	42	40	206	41⅕
8	63½	18¼	4	10	12	12	14	15	9		6 00	62	58	66	60	54	303	60
9	70	13	9½	11	12	16	14	13	12	5	6 17	72	69	70	75	70	356	71⅕
10	61	13¼	6½	9¾	6	9	12	11	10	*	5 22	48	57	51	49	50	255	51
11	65½	14¾	7¼	10⅛	9	10	11	13	8	New wood	4 97	51	55	49	57	49	261	52⅕
12	59	18¼	6½	9½	10	11	11	9	6		5·26	47	50	51	51	48	250	50
13	57	9¼	8¼	9	7	9	9	8	5		4·44	38	36	40	47	41	202	40⅖
14	61½	13	7	9⅜	8	10	9	8	6		4 42	41	36	48	46	45	216	43⅕
15	61½	12¼	8½	9¾	8	10	11	13	7		4 93	49	47	45	48	52	241	48⅕
16	62½	13¼	8½	10	8	9	12	11	New wood		4 04	40	43	38	45	36	202	40⅖
17	62	10¾	9	10	6	11	10	9	10		4 78	46	49	52	47	45	239	47⅘
18	65	13	7	10½	5	13	12	12	10	2	5 34	54	58	52	50	60	274	54⅘
19	66¾	16¼	6¼	10½	7	11	12	10	12	3	5·79	58	66	57	49	61	291	58⅕
20	67½	13¾	6¾	10⅜	9	14	13	16	10	3	5·63	65	55	61	63	59	303	60⅖
21	62¼	15½	5¾	10	12	12	10	9	5		5·54	48	62	56	51	60	277	55⅕
22	59½	11½	7¼	9½	8	10	10	10	5		4 51	43	47	41	40	42	216	43⅕
23	55½	13	5	8¾	6	8	10	7	3		4 25	34	48	40	32	30	184	36⅘
24	60¾	11¼	8¼	9¾	8	10	11	11	6		4 06	46	39	40	35	38	198	39⅗
25	64	12	8¼	10½	8	7	9	12	7		4 33	43	40	45	48	46	222	44⅖
26	67½	13½	8	10¾	8	13	11	11	8	3	4·94	54	50	58	50	54	266	53⅕
27	60	13	6½	9½	8	10	8	5	New wood		3·22	31	35	30	28	29	153	30⅗
28	62½	13½	6½	10	5	8	10	12	7		4·16	42	46	40	42	38	208	41⅗
29	59¼	12	7¼	9½	7	8	8	8	3		3 53	31	36	35	29	34	165	33⅗
30	61¾	13	6½	9¾	6	7	7	8	4		3 24	32	32	35	33	26	158	31⅗
31	69½	17½	5½	11	7	8	10	8	7	New wood	4·18	40	38	53	49	50	230	46
32	59½	12	7¼	9½	8	9	11	7	4		4 12	39	41	44	40	46	210	42
33	61¼	12	8	9¾	7	8	12	10	7		4 28	41	36	42	39	48	209	41⅘
34	68½	12	9½	11	7	9	11	10	10	4	4 52	51	50	54	48	46	219	49⅕
35	61¾	13	7⅜	9¾	9	12	11	9	5		5 12	46	52	49	47	56	250	50
36	59¼	12	7½	9½	7	9	11	10	8		4 52	40	45	47	38	45	215	43
37	58	11	7¼	9¼	8	9	10	10	5		4·80	42	47	39	49	45	222	44⅖
38	62¾	12	8¼	10	10	11	11	10	9		5·22	51	50	54	51	55	261	52⅕
39	61	11	9¼	10¼	10	11	13	11	10	1	5 14	56	54	58	56	53	277	55⅘
40	64	12	9½	10½	11	13	12	11	8	New wood	5·26	55	58	54	50	53	270	54
41	65¾	11¾	7	10½	9	10	10	10	11	2	1 95	52	59	53	52	44	260	52
42	60½	10½	9	9½	6	9	10	9	6		3 83	40	31	38	36	31	182	36⅘
43	53½	10½	6½	8½	8	9	6	6	2		4 14	31	39	35	31	37	176	35⅕
44	60¼	14	6¼	9¼	10	9	9	8	4		5·03	40	51	49	47	49	239	47⅘
45	69½	13	8½	11	12	13	12	13	11	1	5 54	65	59	57	64	60	305	61
46	64	12	8¾	10¼	8	12	11	11	6	New wood Do	1 71	18	54	43	53	45	243	48⅗
47	69	15	8	11	8	11	10	11	6		1 54	46	58	49	53	44	250	50
48	63¾	11¼	9	10½	9	12	10	11	11		5 01	53	56	48	51	49	257	51⅘
49	60¾	12½	8	9¾	6	11	11	12	8		4 75	48	46	45	48	45	232	46⅘
50	67½	13¾	7½	10⅜	8	12	11	11	4	New wood	4·68	46	52	51	51	49	252	50⅖

50/ 239·61/ 4·79, or say 5· rings or years per inch of radius.

* Where "new wood" is written the wood was spongy, and it was impossible to count the rings.

Appendix III.

YOUNG SÁL TREE No. 1.

Number.	Length of piece.	Measured circumference with bark.	Calculated (3¼) diameter with bark.	Thickness of two barks.	Calculated diameter without bark.	Calculated radius without bark.	Estimated number of rings.	Rings (or years) per inch of radius.	Remarks.
	Feet-Inches.	Feet-Inches.	Inches.	Inches.	Inches.	Inches.			
A′	-6	1-10	7·	·75	6·25	3·12	15	4·80	In ground.
B′	-6	1-10	7·	·75	6·25	3·12	15	4·80	
C′	1-7	1-9½	6·84	·75	6·09	3·04	15	4·93	
D′	1-7	1-9¼	6·76	·75	6·01	3·00	14	4·66	
E′	1-6½	1-9½	6·84	·75	6·09	3·04	13	4·27	4·36
F′	1-5½	1-8¾	6·60	·75	5·85	2·92	13	4·45	
G′	1-7½	1-7	6·04	·75	5·29	2·64	12	4·54	4·58
H′	1-6½	1-6¾	5·96	·75	5·21	2·60	12	4·61	
I′	1-6½	1-6	5·73	·75	4·98	2·49	11	4·41	
J′	1-6½	1-6	5·73	·75	4·98	2·49	11	4·41	
K′	1-7½	1-6	5·73	·75	4·98	2·49	10	4·01	11 would give 4·41.
L′	1-6	1-5½	5·56	·70	4·86	2·43	10	4·11	
M′	1-6½	1-5	5·41	·63	4·78	2·39	10	4·18	
N′	1-7	1-4½	5·25	·63	4·62	2·31	10	4·32	
O′	1-6½	1-4½	5·25	·63	4·62	2·31	10	4·32	
P′	1-7	1-3½	4·93	·63	4·30	2·15	9	4·18	
Q′	1-9	1-3½	4·93	·63	4·30	2·15	9	4·18	
R′	1-3½	1-2½	4·61	·63	3·98	1·99	8	4·02	
S′	1-6	...	4·61	·63	3·98	1·99	8	4·02	Calculated.
T′	1-6	...	4·45	·63	3·82	1·91	7	3·66	Ditto.
U′	1-6	...	4·30	·62	3·68	1·84	7	3·80	Ditto.
V′	1-3	1-1½	4·30	·62	3·68	1·84	7	3·80	
W′	1-6½	1-0¾	4·05	·62	3·43	1·71	6	3·51	
X′	1-7	1-0	3·81	·62	3·19	1·59	6	3·77	
Y′	1-7	-11½	3·66	·62	3·04	1·52	5	3·29	
Z′	1-7	-10	3·18	·62	2·56	1·28	5	3·90	
Fork	1-7	-8	2·54	·62	1·92	·98	4	4·08	
Living stem	6-4	...	...	...	...	...	...	...	Calculated from No. 2 tree.
Tip ...	2-8	...	...	...	...	...	...	...	Calculated.
Total ...	48-5½ or say 50 feet.	...	...	...	...	...	...	...	For whole tree.

Appendix IV.

YOUNG SÁL TREE No. 2.

Number.	Length of piece.	Measured circumference with bark at top.	Calculated diameter with bark.	Thickness of two barks.	Calculated diameter without bark.	Calculated radius without bark.	Estimated number of rings.	Rings (or years) per inch of radius.	Remarks.
	Feet-Inches.	Feet-Inches.	Inches.	Inches.	Inches.	Inches.			
1	-6	1-8	6·36	1·	5·36	2·68	7	2·61	In ground.
2	-6	1-8	6·36	1·	5·36	2·68	7	2·61	
A	-1½	1-8	6·36	1·	5·36	2·68	7	2·61	
B	-3½	1-7½	6·20	1·	5·20	2·60	7	2·69	
C	1-7	1-7	6·04	1·	5·04	2·52	7	2·77	
D	1-7	1-6	5·73	1·	4·73	2·36	7	2·96	6½ would give 2·75.
E	1-7	1-5½	5·57	1·	4·57	2·28	6	2·63	
F	1-7	1-5	5·41	1·	4·41	2·20	6	2·72	
G	1-7	1-4½	5·25	1·	4·25	2·12	5	2·36	5½ would give 2·59.
H	1-7	1-3	4·77	1·	3·77	1·88	5	2·66	
I	1-7	1-1½	4·30	·75	3·55	1·77	4	2·26	
J	1-7	1-1½	4·30	·75	3·55	1·77	4	2·26	
K	1-7	-10	3·18	·70	2·48	1·24	4	3·22	3½ would give 2·82.
L	1-7	-9½	3·02	·70	2·32	1·16	3	2·58	
M	1-7	-9¼	2·94	·65	2·29	1·14	3	2·63	
N	1-7	-8½	2·70	·62	2·08	1·04	3	2·88	
O	1-7	-8	2·54	·56	1·98	·99	2	2·02	2½ would give 2·52.
P	1-7	-7	2·23	·50	1·73	·86	2	2·32	
Q	1-7	-5½	1·75	·35	1·40	·70	2	2·85	
R	1-7	-4¾	1·51	·30	1·21	·60	1	1·66	1½ would give 2·5.
S	1-7	-3	1·00	·25	·75	·37	1	2·70	
	2-8	...	...	...	...	...	...	...	
Total ...	31 feet.	...	...	...	...	...	...	...	

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